Memorandum

ARUP

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Copies	Mike King, Arup Emma Bennet, Arup	Reference number	256385-10
From	Jane Nixon, Arup Adrian Callus, Arup	File reference	Memo 01 rev 02 –CEN retain
Subject	Centenary building – Impact assessment on adjacent structures.		

1 Introduction

Following on from the "*WMH- Retention and later deflection*" (Memo01 rev 01 - 29/09/2017) issued, this memo summarises the impact on the structures in the vicinity of the proposed Centenary Building excavation based on the current design documented on structural drawings. The structures considered as part of this assessment are the Perkins Building and buried services in Rosebay Avenue.

The impact assessment is based on the results of the analysis carried out during the detailed design of the Centenary Building retention system. The results of the retention analysis are summarised in our design report Memo 02 rev 3 "*Centenary Building Retention Design*" (dated 01 October 2018). Settlement and lateral displacement contours behind the retention have been prepared based on the estimated lateral deflection of the retention system, and formed the basis of this impact assessment.

A large proportion of the excavation occurs next to existing Perkins building. As well as potentially effecting buried services along Rosebay avenue.

This memo summaries the expected settlements and then provides description the extent of damage expected to the walls of the Perkins Building and buried services.

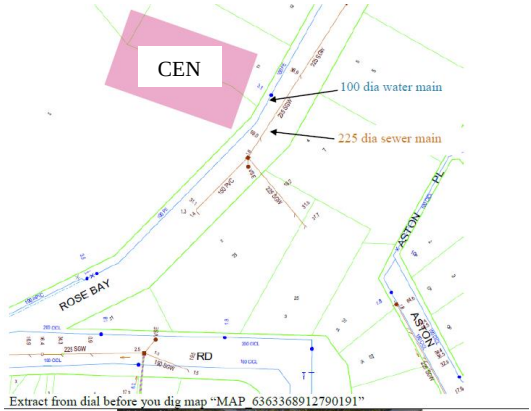
2 Existing information

From the existing information available to us, the Perkin building appears to be a two story high masonry building support on shallow foundations. Several test pits have been completed by Douglas Partners along the northern face of the Perkins Building to determine the footing depth. The results are presented in the revised geotechnical report (Ref: 84944.02.D), and exposed variable founding depths ranging from 0.3m to 3.3m below the existing ground surface level, with the majority founded at 0.5m depth. Typically the building appears to be founded on natural sand, hence any settlement of the founding sand for the building is likely to result in cracking and damage of the Perkins building.

For the purposes of the retention design and this impact assessment, it has been assumed that the Perkins Building is uniformly founded at 0.5m depth below existing ground level.

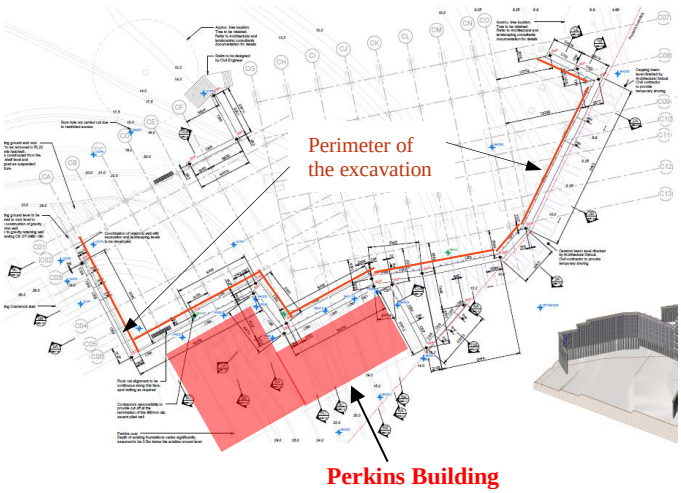
It is noted that the existing buried services within Rosebay Avenue have not been surveyed, therefore their location is approximate. The following services have been identified along Rosebay Avenue based on Dial Before You Dig information.

Buried service/Asset owner	Service details
Water Main/Sydney Water	Polyethylene and PVC pipe
Sewer/Sydney Water	Salt Glaze ware and PVC pipe
Jemena	32mm Nylon inserted into 4inch cast iron main
Ausgrid	50mm to 150mm cables/ducts and concrete culverts.
NBN	Fibre optic duct



Extract from dial before you dig map "MAP_6363368912790191"

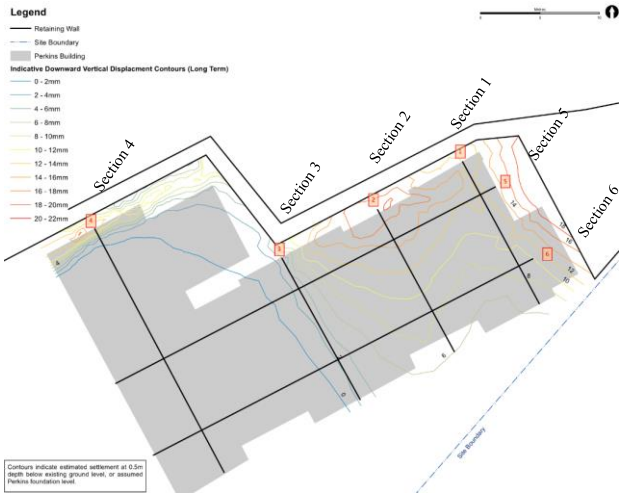
View up Roase Bay Avenue



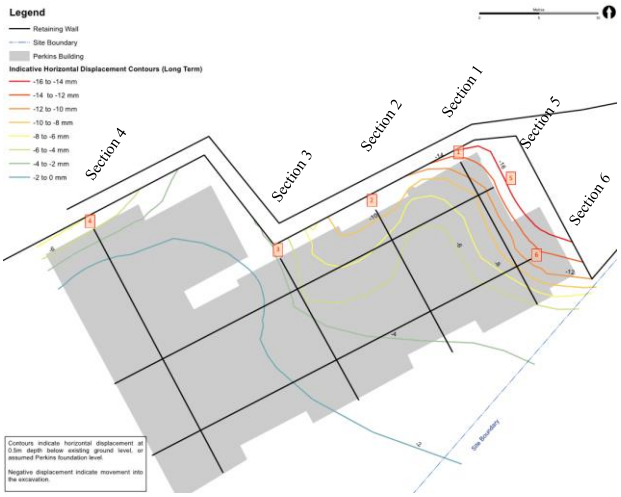
3 Assessment of ground movements

In order to complete the impact assessment, estimated of the behind wall movements, both vertical (settlement) and lateral (horizontal movements) is required. As the analysis has been carried out using Plaxis, an estimate of the settlements and horizontal movements are calculated as part of the analysis.

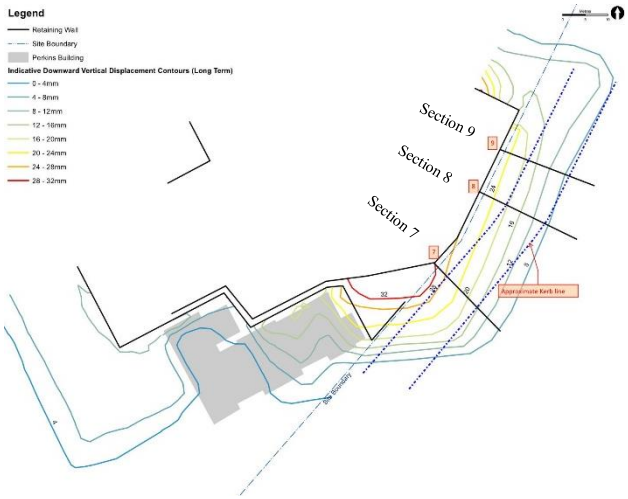
The results of the analysis are provided in the design memo (Memo 02 rev 3), however, for ease of reference the estimated vertical and horizontal displacements, at Perkins foundation level (ie. 0.5m below ground level), and at surface level along Rosebay Avenue are reproduced below.



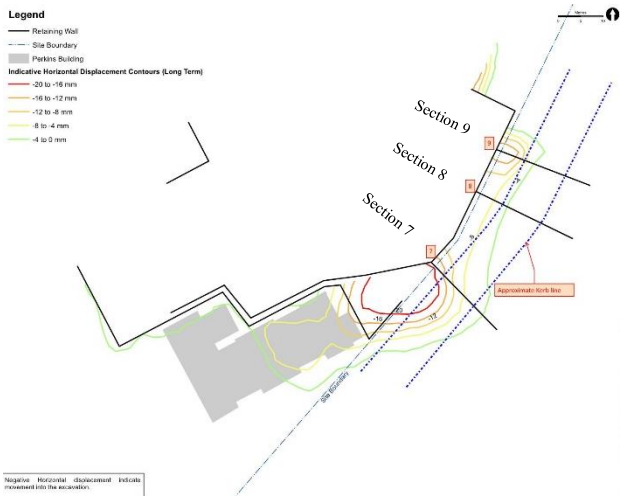
Perkins Building Foundation – Vertical displacement/Settlement



Perkins Building Foundation – Horizontal displacement (towards excavation)



Existing Ground – Vertical displacement/Settlement



Existing Ground - Horizontal displacement (towards excavation)

4 Criteria

4.1 Perkins Building

The Australian standard into residential slabs and footing (AS 2870) provides guidance on acceptable values for acceptable deformation parameter of a building subject to differential settlement.. The code states a maximum differential footing defection of L/800, 15mm max for articulated full masonry and L/2000 , 10mm max for full masonry.

For designs within this limit it would be expected the footing and resulting wall cracking performance would achieve a Category 0 (Negligible) to 1 (Very Slight) crack performance.

TABLE 4.1

MAXIMUM DESIGN DIFFERENTIAL FOOTING DEFLECTION (Δ) FOR DESIGN OF FOOTINGS AND RAFTS

Type of construction	Maximum differential deflection, as a function of span, mm	Maximum differential deflection, mm
Clad frame	L/300	40
Articulated masonry veneer	L/400	30
Masonry veneer	L/600	20
Articulated full masonry	L/800	15
Full masonry	L/2000	10

Adopted design criteria from AS 2870. This achieves performance of Negligible, very slight cracking in walls

4.1.1 Damage classification

The classification for damage in the structure as a result of foundation movement is proposed by AS 287 as well as C760 CIRIA guidance. The classification of damage is split into 6 categories and resulting crack width, providing a qualitative description of possible damage.

Table 6.4 Classification of visible damage to walls (after Burland et al, 1977, Boscardin and Cording, 1989, and Burland, 2001)

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain, ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	<0.1	0.0 to 0.05
1 Very slight	**Fine cracks that can easily be treated during normal decoration.** Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection	<1	0.05 to 0.075
2 Slight	**Cracks easily filled. Redecoration probably required.** Several slight fractures showing inside of building. Cracks are visible externally and **some repointing may be required externally** to ensure weathertightness. Doors and windows may stick slightly.	<5	0.075 to 0.15
3 Moderate	**The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced.** Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5 to 15 or a number of cracks >3	0.15 to 0.3
4 Severe	**Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.** Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Services pipes disrupted.	15 to 25, but also depends on number of cracks	>0.3
5 Very severe	**This requires a major repair, involving partial or complete rebuilding.** Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually >25, but depends on numbers of cracks	

Notes

1 In assessing the degree of damage, account must be taken of its location in the building or structure.

2 Crack width is only one aspect of damage and should not be used on its own as a direct measure of it.

From "Guidance on embedded retaining wall design" C760, CRIA,2017
Similar table is provided in AS 2870 (appendix C, table C1)

4.2 Buried services

The following criteria has been adopted for buried services assessment.

Buried Service	Preliminary Stage Assessment
Concrete or Vitrified clay pipe	1:500 slope (0.20%) and/or 25mm absolute
Concrete drains	1:500 slope (0.20%)
Power Cables	1:150 slope (0.67%) and/or 100mm absolute settlement
Telecom – ducts/cables	1:50 slope (2.00%)
Telecoms chambers	25mm settlement

O'Rourke and Trautman (1982) provide an empirical method of damage assessment for cast iron and ductile iron pipelines, based on the slope created in the pipeline, as described below.

Description of pipe	Limit of S_{max}/i (from Gaussian settlement curve)	Slope
Relatively rigid pipes, more than 200mm diameter	0.012	1:140
Relatively flexible pipes, less than 200mm diameter	0.012 to 0.040	1:40 to 1:140

The above criteria has been adopted based on previous project experience, and therefore is considered appropriate. It is recommended that this criteria is discussed and agreed with asset owners (eg Sydney Water, Jemena Gas and Telstra). Unless other requirements become apparent it is assumed that the above preliminary assessment criteria is sufficient. Further, the assumed deflections, at surface or at the retention face, hence it is anticipated services will experience equivalent to or less deflection.

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5 Impact of settlement

The tables below summarise the impact of the proposed excavation on the Perkins Building and the buried services along Rosebay Avenue. Refer to section 3 figures for section locations

5.1 Perkins Building

	Perkins Foundation						
	Settlement				Horizontal Displacement		
	Maximum Settlement (mm)	Max Differential (mm)	Overall Gradient	Local edge gradient	Maximum Displacement (mm)	Max Differential (mm)	Maximum Gradient
Section 1	16	10	1:1400	L:1400	14	8	1:1750
Section 2	18	12	1:992	L:1000	12	8	1:1500
Section 3	6	12	1:2333	L:1000	6	8	1:3375
Section 4	12	12	1:1083	L:200	6	6	1:3833
Section 5	14	14	1:2595	L:1000	14	14	1:2595
Section 6	10	10	1:3633	L:2000	12	12	1:3028

In summary:

- Expected differential settlement of 10-14mm across and under the Perkins building
- Typically majority of Perkins is expected to have differential settlement resulting in a Damage Category 2 – Slight (less than 5mm crack width)
- North western corner (Section 4 – West of 900 dia secant wall) of Perkins is expected to have local narrow differential settlement resulting in a Damage Category 3- Moderate (5 to 10mm crack widths).
- While the north western corner may need additional repair it is noted that it is expected damage to be generally superficial and aesthetic damage, without major structural impact to the building.

5.2 In ground services

Rose Bay Avenue- Buried Services				
	Settlement			Horizontal Displacement
	Maximum Settlement (mm)	Max Differential (mm)	Maximum Gradient	Maximum Displacement (mm)
Section 7	32	24	1:854	20
Section 8	24	20	1:845	8
Section 9	24	20	1:855	16

Based on the results the maximum differential movements and gradients estimated at surface level along Rosebay Avenue satisfy the adopted criteria summarised above. Therefore, no further assessment is required.

In summary; settlements are in line with proposed criteria however it is noted that, criteria is discussed and agreed with asset owners (eg Sydney Water, Jemena Gas and Telstra).

6 Construction

It is noted that estimated settlements have been based on a series of analysis carried out on the best assessment of design assumptions at the time of the design. Conditions could vary on site during excavation and construction, hence it is recommended that the following steps are put together before and during construction;

- A dilapidation survey is to be carried out before start of the work on site. This provides a clear base line and point at which to measure changes/movements against.
- It would then be expected that regular monitoring is carried out throughout the works. This would be done at regular frequency as well as key stage of the works and/or heavy rain to bench-mark movement against design.
- Design is based on the final building works. Design and assessment of temporary works for the construction needs to be carried out by the Contactor and Geotechnical engineer to ensure stability of the site and retention systems in the temporary stages of construction.
- Prior to start of the work a mitigation plan is prepared should excessive movement and damage occur during construction works. It would be expected that this should include establishment of the location of stop values for effected services so that such services can be terminated ASAP is there is damage on site.